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Sir:

For the Examiner's convenience, enclosed herewith is a copy of the English translation of Japanese Patent Application No. S58-88780. It should be noted that the reference herein cited, was previously submitted to the U.S. Patent and Trademark Office with the Information Disclosure Statement filed on September 25, 2006 and therefore, is not enclosed herewith.

Respectfully submitted,

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(54)TITLE OF THE INVENTION: MATRIX TYPE LIQUID-CRYSTAL DISPLAY DEVICE

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SPECIFICATION

TITLE OF THE INVENTION

MATRIX TYPE LIQUID-CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to a TFT array that is used in a matrix-type liquid-crystal display device that comprises a plurality of gate lines, and a plurality of source lines that orthogonally cross the gate lines, and where there are active elements such as TFT and storage capacitors at the points of intersection, and more particularly to the structural design of the TFT, display electrodes and storage capacitors. FIG. 1 is a drawing for explaining the construction of a TFT array, and FIG. 2 is a drawing for explaining the construction of a matrix-type liquid-crystal display device.

In the figures, (1) is a gate line, (2) is a source line, (3) is a

drain electrode, (4) is a TFT, (5) is a display electrode, (6) is a storage capacitor, (7) is a liquid crystal, (8) is a TFT array, (9) is a TFT array substrate, (10) is a transparent conductive film, (11) is a color filter, (12) is an opposing substrate, and (13) is a matrix-type liquid-crystal display device.

FIG. 3 and FIG. 4 show an example of a conventional device of this type. FIG. 3 is a top view of a TFT array element, and FIG. 4 is a cross-sectional drawing showing the section IV-IV of FIG. 3.

In the figures, (1) is a gate line, (2) is a source line, (3) is a drain electrode, (5) is a display electrode, (8) is a TFT array, (9) is a TFT substrate, (14) is a gate insulating film, (15) is a semiconductor, (16) is a protective film, (17) is a storage capacitor electrode, and (18) is a dielectric.

(3)

First, the construction of the matrix-type liquid-crystal display device will be explained according to FIG. 1 and FIG. 2. The matrix-type liquid-crystal display device is constructed so that it comprises: a TFT substrate (9) of a TFT array (8), which comprises a plurality of gate lines (1) and a plurality of source lines (2) that orthogonally cross these gate lines (1), with active elements, such as a TFT (4), formed at the points of intersection, having a drain electrode (3), display electrode (5) and storage capacitor (6); an opposing substrate (12) that faces the TFT substrate (9) and that has a transparent conductive film (10), and color filter (11) for colors such as red, green or blue; and liquid crystal (7) that is located and held between both of these substrates (9), (12).

Next, a conventional TFT array (8) will be explained according to FIG. 3 and FIG. 4. The TFT array (8) has an evaporation film made from Al or

the like that is formed as a gate electrode (1) on the surface of a TFT array substrate (9) that is made from an insulating substrate such as glass, and that gate electrode (1) is covered by a sputtering film such as SiO_2 as a gate insulating film (14). Amorphous silicon or the like is formed on top of that as a semiconductor (15) by a method such as the plasma CVD method, and on top of that, an evaporation film made from Al or the like is formed as a source line (2) and drain electrode (3), and SiN or the like is formed using a method such as the plasma CVD method on the surface as a protective layer (16). Next, In_2O_3 or the like is formed by a method such as evaporation as a storage capacitor electrode (17), and SiO_2 is formed using a method such as sputtering as the storage capacitor dielectric (18), after which In_2O_3 or the like is formed by a method such as evaporation as a display electrode (5) and is connected to the previously formed drain electrode (3) to complete the TFT array (8).

Next, the operation of the TFT array (8) and matrix-type liquid-crystal display device (13) will be explained with reference to FIG. 5, and FIGS. 1 to 4. Here, FIG. 5 is a drawing for explaining the operation of a TFT, and shows the relationship between the drain current and mutual conductance (gm). As characteristics that are desired for a TFT array that is used in matrix-type liquid-crystal display, it is necessary that the ratio between the drain current when the TFT is OFF (IDS(OFF)), that the drain current when the TFT is ON (IDS(ON)) IDS(ON)/IDS(OFF) be 10^3 or greater, and that the mutual conductance (gm), which indicates the sensitivity and gain of the TFT, be large. Here, in a TFT that uses amorphous silicon, the surface mobility (μ) of the carriers in the semiconductor near the boundary of the semiconductor and gate insulating film is very small compared with that of when a single-crystal semiconductor (for example, 0.5μm2/v・sec) is used, so it is difficult to obtain the voltage (current) necessary to drive the liquid-crystal, and it is necessary to form a very large TFT (large channel width (w)/channel length (l) ratio), however, due to partition technology constraints, the channel length (l) is limited by

how small it can be made, therefore it is necessary to increase the channel width (w), and as shown in FIG. 3, construction is such that there is a large TFT and small display electrode. On the other hand, in an image display of a matrix-type liquid-crystal display, due to resolution constraints, the maximum dimensions of a unit picture element must be approximately 3000 micron meters or less.

As explained above, the prior art has disadvantages in that, normally, as a result of the installation area on the display of the TFT that becomes the problem becoming large, and the area of the installation area of the display electrode becoming small, the amount of the unit picture element area that is occupied by the display electrode, which is an indicator of the display performance, or in other words the aperture ratio (hereafter referred to as the aperture ratio) decreases, and it is not possible to obtain a matrix-type liquid-crystal device that has good display performance.

SUMMARY OF THE INVENTION

In order to eliminate the disadvantage of the prior art described above, the object of the present invention is to provide a matrix-type liquid-crystal device in which the construction of TFTs of the TFT array and display electrodes that are used in the matrix-type liquid-crystal display device are improved, and that has a high aperture ratio and good display performance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a drawing explaining the construction of a TFT array.

FIG. 2 is a cross-sectional drawing of a matrix-type color liquid-crystal display device.

FIG. 3 is a top view of a prior TFT array picture element.

FIG. 4 is a cross-sectional drawing of section IV-IV in FIG. 3.

FIG. 5 is a drawing for explaining the operation of a TFT.

FIG. 6 is a top view of a TFT array picture element of a first embodiment of the invention.

FIG. 7 is a cross-sectional drawing of section VII-VII in FIG. 6.

FIG. 8 and FIG. 9 are both top views of other embodiments of the invention.

In the figures, (1) is a gate line, (2) is a source line, (3) is a drain electrode, (4) is a TFT, (5) is a display electrode, (6) is a storage capacitor, (7) is a liquid crystal, (8) is a TFT array, (9) is a TFT array substrate, (10) is a transparent conductive film, (11) is a color filter, (12) is an opposing substrate, (13) is a matrix-type liquid-crystal display device, (14) is a gate insulating film, (15) is a semiconductor, and (18) is a dielectric material.

The same reference numbers are used in each of the drawings for identical or corresponding parts.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiment of the present invention is explained below based on FIG. 6 and FIG. 7. FIG. 6 is a top view of a picture element of the TFT array of this embodiment of the present invention, and FIG. 7 is a cross-sectional drawing of the section VII-VII of FIG. 6. In the figures, (1) is a gate line, (2) is a source line, (3) is a drain electrode, (5) is a display electrode, (8) is a TFT array, (9) is a TFT array substrate, (14) is a gate insulating film, (15) is a semiconductor, (16) is protective film, (17) is a storage capacitor electrode and (18) is a dielectric.

Next, the construction will be explained. A TFT array (8) is formed by successively arranging a gate electrode (1), gate insulating film (14), semiconductor (15), source line (2), drain electrode (3), protective film (16), storage capacitor electrode (17), dielectric (18) and display electrode (5) on the surface of a TFT array substrate (9) that is made from

transparent insulating substrate such as glass using the same method as the conventional method described above.

Next, the function and operation of the TFT array (8) and matrix-type liquid-crystal display device of this invention will be explained. As shown in FIG. 6, the TFT is formed so that it surrounds the entire display electrode; therefore forming a TFT having a large channel width (w) can be easily performed, and the drain current when the TFT is ON (IDS(ON)) can be made large, thus it possible to increase the ratio IDS(ON)/IDS(OFF), and make the mutual conductance (gm) large, which improves the sensitivity and gain of the TFT. Also, as a result of improving the aperture ratio, the resolution is also improved. Moreover, as a result of being able to increase the area of contact between the display electrode (5) and drain electrode (3) that are located over the top electrode of the storage capacitor (17), it is possible to reduce line disconnection and improve storage.

FIG. 8 and FIG. 9 are drawings showing other embodiments of the present invention, where FIG. 8 is a drawing of a second embodiment of the invention in which the TFT is formed so that it surrounds the display electrode (5) on only two sides of the display electrode (5), and FIG. 9 is a drawing of a third embodiment in which the TFT is formed so that it surrounds the display electrode (5) on only one side of the display electrode (5); and here both the second and third embodiments shown in FIG. 8 and FIG. 9 are used in cases when the unit picture element is made to be larger than that of the first embodiment shown in FIG, 6 and FIG, 7, and when it is possible to form a TFT having surface mobility (μ) that is larger than that of the first embodiment, while still being capable of displaying the same effect as that of the first embodiment 1.

As explained above, with this invention, as a result of increasing the TFT channel width (w) and increasing the aperture ratio, the current

when the TFT is ON increases, the IDS(ON)/IDS(OFF) ratio becomes large, the mutual conductance (gm) becomes large, the TFT sensitivity and gain are improved, and a TFT array made using amorphous silicon and that has low surface mobility (μ) is possible, and by increasing the aperture ratio, the resolution and display performance of a matrix-type liquid-crystal display device are improved.

Also, increasing the connection area between the display electrode and source electrode is effective in reducing line disconnection and improving product yield of the TFT array.

WHAT IS CLAIMED IS:

1. A matrix-type liquid-crystal display device comprising:

a substrate on which a thin-film transistor (hereafter referred to as TFT) array is formed from a plurality of gate lines, a plurality of a source lines that orthogonally cross the gate lines, active elements such as TFTs that are located at the intersections, and storage capacitors; an opposing substrate on which transparent conductive film and red, green and blue color filters are formed; and liquid crystal that is located between both of said substrates; wherein the TFTs are formed so that they surround display electrodes.

2. The matrix-type liquid-crystal display device of claim 1 wherein the semiconductor of the TFTs is amorphous silicon or polysilicon.